

# A Convergence Study on Wearing Contact Lenses after Corneal Refractive Surgery

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## 각막굴절수술 후 콘택트렌즈 착용에 대한 융복합적 연구

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**Abstract** Aims of this study was to investigate on the actual condition of contact lens wearing after corneal refractive surgery, base curves and diameters of lenses on sale, and to confirm movement of lens and wear patterns when wearing of lenses in the modified cornea. After surgery, 16.5% of the respondents had experience wearing contact lenses. Also, the mostly distributed contact lenses had B.C. 8.6mm and DIA.14.0mm. The corneas of 24 eye after corneal refractive surgery were flat, the lenses moved towards inferior and temporal when wearing the lens. After corneal refractive surgery, contact lens wear may feel uncomfortable may require the detailed description and sophisticated fitting due to the limited type of contact lens. It is thought that convergence will be necessary in the industry and clinical study of contact lenses.

**Key Words** : Convergence, Corneal refractive surgery, Contact lens, Survey, Base curve, Diameter

요 약 본 연구에서는 각막굴절수술 후 콘택트렌즈 착용 실태, 유통 중인 콘택트렌즈의 베이스커브와 직경을 조사하여, 변형된 각막에 콘택트렌즈를 착용하였을 때 렌즈 움직임과 착용양상을 확인해보고자 하였다. 각막굴절수술 후 16.5%가 콘택트렌즈를 착용한 경험이 있었다. 또한, 콘택트렌즈의 베이스커브는 8.6 mm, 직경은 14.0 mm가 가장 많은 비중을 차지하였다. 각막굴절수술 한 24안의 각막은 편평하였으며, 콘택트렌즈를 착용했을 때 렌즈는 이측과 하측으로 모두 이동하였다. 각막굴절수술 후 콘택트렌즈 착용으로 불편함을 느낄 수 있어 렌즈 착용시 상세한 설명과 한정적인 렌즈의 종류로 정교한 피팅이 필요하며, 콘택트렌즈의 산업과 임상적인 연구에서 융합이 필요할 것이라고 생각된다.

주제어 : 융합, 각막굴절수술, 콘택트렌즈, 설문, 베이스커브, 직경

### 1. Introduction

According to Gallup Korea in 2017, the rate of the wearer of glasses and contact lenses is 60.7%. It was 24% in 1987 and has been steadily increased by more than double[1]. Besides to the method of correcting refractive error, wearing glasses increased for UV blocking[2-4]. In order to escape from the discomfort of

glasses[5], people choose to wear contact lenses instead of glasses for cosmetic purpose[6] and they choose surgical method in case of impossibility of wearing contact lenses. Corneal refractive surgery was initiated as PRK(Photo refractive keratectomy) in 1983 by Trokel et al[7], LASIK(Laser-assisted sub-epithelial keratomy) and LASEK(Laser epithelial keratomileusis) etc. are being used[8]. Techniques have been improved

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and the surgery is practiced in earnest since 1990s in Korea. It is estimated that more than 100 thousand people has received the surgery with variously developed technique[9]. There are several kinds of surgical methods however the fundamental principle is to correct eyesight by ablating cornea to the extent of subject's refractive power with laser. A study reported that the thickness of central cornea is thinner than the peripheral cornea's since the centre zone is ablated more than the peripheral zone[10]. The cornea of non-operated subject has aspheric surface that flattens to the periphery[11]. In other words, corneal radius of the periphery zone is flatter than the central zone's. On the other hand, the shape of centre cornea of operated subject is flat and corneal radius of the periphery zone is steeper than the central zone's[12]. However, there were some cases in which the operated subjects wear contact lenses for cosmetic reasons[13] or the correction of myopic regressive[14]. There is difference between the shapes of cornea of before and after the surgery and it could cause discomfort in wearing contact lenses. However, there is little research. Hereby, Some of those who had corneal refractive surgery to improve some discomforts wear contact lenses on the modified cornea for a cosmetic reason. This study is conducted to find out the degrees of movement of contact lens, discomforts, and wearing sensations of lenses on the modified corneas. We used the most used type of lenses after researching what is the most common base curve and diameter among all that is on sale.

## 2. Methods

### 2.1 Survey subject

This study is targeting 216 adults(15 male, 246 female) who had corneal refractive surgery between June 2015 and September 2015. We conducted a survey on the actual condition of contact lens wearing after corneal refractive surgery.

### 2.2 Examine on the real state of the distribution of soft contact lenses

We examined base curve(B.C.) and diameter(DIA.) of 328 soft contact lenses from 37 companies, which are for sale from June to September 2015.

### 2.3 Wear of Contact Lens After Corneal Refractive Surgery

#### 2.3.1 Subjects

This study is targeting 12 adults (24 eyes) of average age  $22.5 \pm 1.60$ , including 7 females and 5 males. It has been more than 6 months since they have received corneal refractive surgery and they are not showing any symptom of eye diseases and have no recent history of drug use. They received the explanation of the purpose of this study and agreed to proceed. They had LASIK 6 eye and LASEK 18 eye and there was no difference in surgical method.

#### 2.3.2 Experiment method

Contact lenses used for this study were cosmetic contact lens. Which means, subjects wore these lenses for cosmetic purpose. The lenses had 8.6mm of base curve, 14.0mm of diameter, 38% of water content, and S 0.00D of refractive power. We used the corneal topography(OCULUS, Keratograph V 1.65) to measure the shape of subject's cornea. We measured steep corneal curvature(radius), flat corneal curvature(radius), corneal astigmatism of cornea. Frequency of blinking was measured with contact lenses on. We measured 3 times every 1 minute with for using auto refraction keratometer and used the average value so that the subjects were oblivious of the test. Movement was observed using slit lamp(TOPCON, SL-D7). The location of lenses after blinking while looking at front was photographed and the photograph measured the movement of lenses using MICROSOFT OFFICE VISIO 2007. The subjects, who had corneal refractive surgery, answered the subjective symptom questionnaires after wearing the contact lenses. We

used the subjective symptom questionnaires from the study of Park et al.[15] subjects assessed about 8 subjective symptoms including dryness, movement, tickle, itchiness, sting, soreness, teardrop, and eye redness. Each subject was evaluated on a scale of one to five and the more they feel comfortable the higher number they gave.

2.4 Statistical analysis The actual condition of contact lens wearing after corneal refractive surgery

Statistical analysis was applied for every single data using SPSS Statistics 18.0. We displayed the data of the actual condition of contact lens wearing after corneal refractive surgery and base curve and diameter of contact lenses with percentage and descriptive statistic. We marked shape of cornea, movement of contact lenses, and subjective assessment with mean ± standard deviation, and used regression analysis for both horizontal and vertical movement of contact lenses and correction analysis of Spearman for movement of contact lenses, frequency of blinking, and subject symptoms assessment. We determined that there is statistically significant difference if the significance level(p-value) is 0.05 and less on the basis of 95% reliability.

3. RESULTS and DISCUSSION

3.1 The actual condition of contact lens wearing after corneal refractive surgery

Among 261 subjects (15 male, 246 female), 16.5% of them have tried wearing contact lenses after the corneal refractive surgery is shown in Table 1 and 88.4% of them wore cosmetic contact lenses[Fig. 1].

They wore average 7.16±3.18 hours per day. 79.1% of them had subjective symptoms, and 39.5%, 18.6%, 14.0%, 4.7%, and 2.3% of them had the feeling of dryness, movement, eye redness, teardrop, and pain respectively[Fig. 2]. 25.7% of subjects were planning to

wear contact lenses in the future. This result shows that people who went through the corneal refractive surgery actually wear contact lenses and we expect more people will wear them in the future. We assume that the proportion of cosmetic contact lenses is high because the majority of subjects were female and they are more likely to wear lenses for a cosmetic purpose[16] than male. They wear average 7 hours a day and they answered that they are having subjective discomforts. It is different than the recommended wearing time of cosmetic contact lenses, which is 4hours[17]. Long-term use of contact lenses could damage corneal epithelium and this could progress to some illness such as corneitis. Thus, an optician should give a detailed explanation[18] of the side effect, subjective symptoms, and wearing time.

Table 1. Usage state of contact lenses after corneal refractive surgery

Questionnaire	Yes(%)	No(%)
I have experienced contact lens wear after corneal refractive surgery.	16.5	83.5
I experienced subjective symptoms when wearing a contact lens.	79.1	20.9
I plan to wear a contact lens.	25.7	74.3

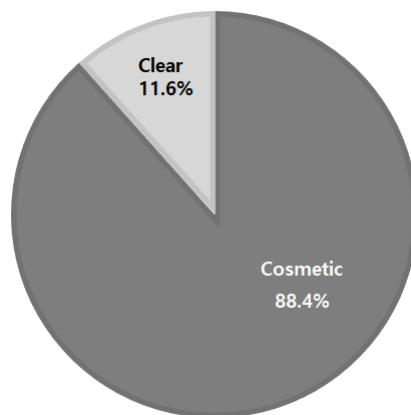


Fig. 1. Types of contact lenses worn after corneal refractive surgery

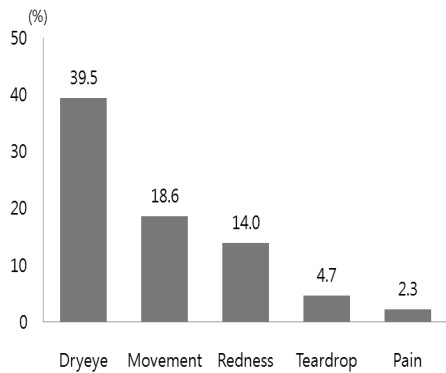
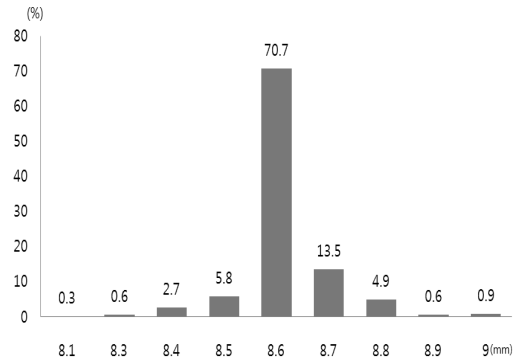


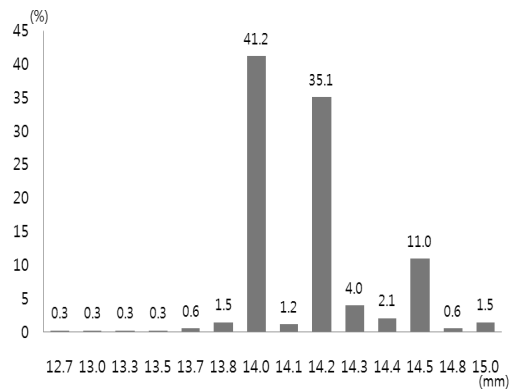
Fig. 2. Subjective symptoms of uncomfortable after wearing contact lenses

### 3.2 Examine the base curve and the diameter of contact lens

We examined base curve(B.C.) and diameter(DIA.) of 328 soft contact lenses from 37 companies, which are for sale, and 106 of them were clear lenses for visual correction and 222 of them were for cosmetics. 4.0%(13) of them had 8.1mm of base curve, 0.6%(2) had 8.3mm, 2.7%(9) had 8.4mm, 5.8%(19) had 8.5mm, 70.7%(232) had 8.6mm, 13.5%(44) had 8.7mm, 4.9%(16) had 8.8mm, 0.6%(2) had 8.9mm, and 0.9%(3) had 9.0mm. Among 37 companies, 37.8%(14) of them produced only one type of base curve and diameter. 0.3%(1) of them had 12.7mm of diameter, 0.3%(1) had 13.0mm, 0.3%(1) had 13.3mm, 0.3%(1) had 13.5mm, 0.6%(2) had 13.7mm, 1.5%(5) had 13.8mm, 41.2%(135) had 14.0mm, 1.2%(4) had 14.1mm, and 35.1%(115) had 14.2mm, and 4.0%(13) had 14.3mm, and 2.1%(7) had 14.4mm, and 11.0%(36) had 14.5mm, and 0.6%(2) had 14.8mm, and 1.5%(5) had 15.0mm[Fig. 3]. Also, only 1.52%(5) of them produced the different base curve for one type of lens. The mostly distributed contact lenses had B.C. 8.6mm and DIA.14.0mm. 70.7% of contact lenses on the market have B.C. 8.6mm, 41.2% of them had DIA.14.0mm, and 35.1% of them had DIA.14.2mm. Since two sizes take up more than half of the market, the customers have a very limited range of options. This could cause some problems for the contact lens fitting condition.



(A)



(B)

Fig. 3. Actual investigation of contact lens in Korea (A) Base curve, (B) Diameter

### 3.3 Wear of contact lens after corneal refractive surgery

#### 3.3.1 Corneal shape of contact lens wearer

Corneal shape of contact lens wearer is shown in Table 2. Corneal topography showed that the average flat corneal curvature was  $39.02 \pm 2.09D$  and the corneal radius was  $8.65 \pm 0.38mm$ , and the average steep corneal curvature was  $40.01 \pm 1.94D$  and the corneal radius was  $8.44 \pm 0.38mm$ , and the average corneal astigmatism was  $0.99 \pm 0.44D$ . It was shown that the corneal shape of the subject who had corneal refractive surgery was flat. The previous study of Lee et al.[19] demonstrated the similar result with this study showing that the subjects' cornea was flattened after the surgery. In that study, before LASIK, the preoperative corneal curvature was  $43.75 \pm 1.03D$  and it became  $39.29 \pm 1.66D$

after the surgery. Jung et al.[20] reported that non-operated university students' average corneal radius are  $7.94 \pm 0.22\text{mm}$  for flat corneal radius and  $7.76 \pm 0.23\text{mm}$  for steep corneal radius. Park and Kim[21] reported that corneal refractive surgery operated subjects' average corneal radius are  $8.41 \pm 0.31\text{mm}$  for flat corneal radius and  $8.21 \pm 0.34\text{mm}$  for steep corneal radius. The values of those studies seem similarly flat as this study. We could learn that the shape of corneas, which were ablated with laser, was flatter than those weren't. After corneal refractive surgery, the prescribed contact lenses are normally for flattened cornea[22] and we suppose that one need to give better attention to relatively more flat cornea when they put on contact lenses.

Table 2. Corneal shape data of the subject

Variable	Mean±SD
Flat K(D)	$39.02 \pm 2.09$
Steep K(D)	$40.01 \pm 1.94$
Corneal astigmatism(D)	$0.99 \pm 0.44$

### 3.3.2 The center of contact lens in corneal refractive surgery subject

In 24 eye, which is stabilized with wearing contact lenses, the centre location of contact moved towards inferior in vertical direction and towards temporal in horizontal direction. The centre location of contact lens is demonstrated in Fig.4. From corneal vertex, lenses moved average  $1.75 \pm 0.82\text{mm}$  towards temporal and  $2.80 \pm 1.26\text{mm}$  towards inferior[Fig. 5].

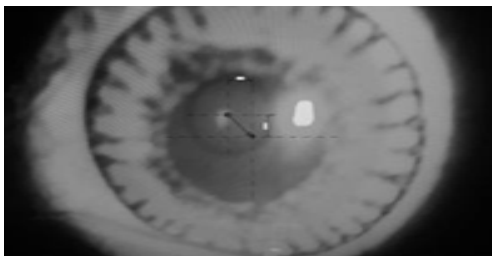


Fig. 4. Center location of contact lens wearing after corneal refractive surgery(Right eye).

It moves more in vertical direction than in horizontal direction. Each movement of 1mm from corneal vertex towards temporal was followed by the movement of 0.63mm towards inferior( $F=4.427, p=.047$ ).

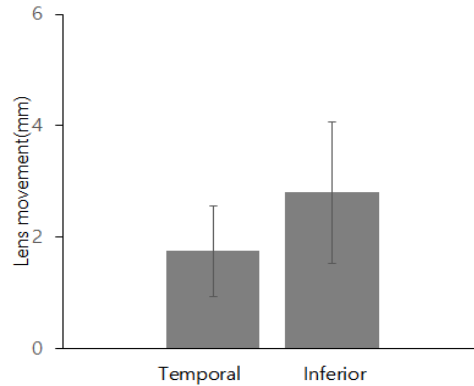


Fig. 5. contact lens movement after contact lens wearing

In addition, the centre location of lenses moved  $3.50 \pm 0.93\text{mm}$  from corneal vertex. Every time they move 1mm towards inferior and temporal, the distance between corneal vertex and the centre of lenses increased by 0.78mm and 0.55mm respectively( $F=64.596, p=.000$ ). In normal state of fitting, there should be about 1mm of movement when looking at front after blinking[22]. We had to try different type of the base curve but most of the cosmetic contact lenses sold in Korea had 8.6mm of base curve. We suppose that various type of base curve is needed for shape-modified cornea since there is discomfort in wearing. Park et al.[23] reported that the movement of contact lenses decreases when the water content is higher. The tendency of higher water content contact lenses to collect foreign substance changes the shape of contact lenses and this interfere the circulation of teardrops[24]. The percentage of water content of the contact lenses used in this study was 38% and we consider additional study is required to clarify the difference between various rates of water content[25]. Another study also reported that the movement of contact lenses is influenced by the wearing time and

whether the lenses made of the same material are stained or not[26]. It is thought that we need to put consideration at various angles before wearing contact lenses after corneal refractive surgery since there are various factors that affect the movement of lenses.

### 3.3.3 Movement of contact lens and blinking

Subjects' average frequency of blinking was  $26.31 \pm 7.65$  times per minute. Also, the movement of contact lenses towards inferior in vertical direction has relevance to the frequency of blinking ( $r=0.449$ ,  $p=.028$ ) [Fig. 6] but the movement in horizontal direction does not ( $r=0.153$ ,  $p=.474$ ). The average frequency of blinking in normal state is 12 times per minute [22]. The study of Park et al. [27] reported that the average frequency of blinking immediately after wearing the contact lenses on is more than 25 times per minute and the similar result with this study showing that who are wearing cosmetic contact lenses blinks more frequently. It is thought that the frequency of blinking has increased because the lenses move towards inferior more since there were changes in the shape of cornea [20]. Additional research should be followed on the effect of lens worn time [27] and the pressure of the eye [28] to the frequency of blinking.

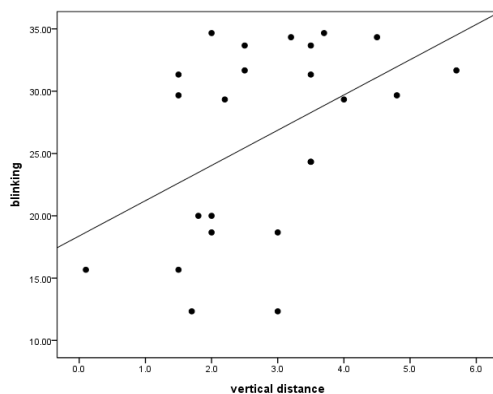


Fig. 6. A scatter plot of the effect of blinking on vertical distance movement.

### 3.3.4 Subjective symptom

We conducted subjective symptom questionnaires

right after subjects wear the contact lenses. After wearing the contact lenses, in the order they gave were  $3.50 \pm 0.44$  for movement, and it was followed by  $2.50 \pm 0.34$  for itchiness,  $2.25 \pm 0.37$  for sting,  $2.08 \pm 0.29$  for dryness,  $1.92 \pm 0.36$  for tickle and  $1.92 \pm 0.34$  for teardrop,  $1.83 \pm 0.37$  for eye redness, and  $1.58 \pm 0.19$  for soreness [Table 3]. The reason why the movement acquired the highest number is that the lenses deviated the centre of cornea. The movement of lenses and feeling of movement were correlative ( $r=0.493$ ,  $p=.034$ ) and the further the lenses go, the higher number they were given. Non-operated subjects wearing cosmetic contact lenses for a long time showed 15% of dryness and itchiness and 14% of tiredness [29]. There was difference in subjective symptoms between operated and non-operated subjects. But other than dryness, itchiness, sting, and dryness showed similar aspect even after wearing for a long time. The surgery damages sensory nerves of cornea and lowers the sensory perception. It leads to the decrease of frequency of blinking and teardrops, which eventually make the eyes dry [30,31]. It is thought that contact lenses will put more dryness into the dry eyes [32,33].

Table 3. Mean of subjective symptom scores

Symptom	Mean $\pm$ SD
Dryness	2.08 $\pm$ 0.29
Movement	3.50 $\pm$ 0.44
Tickle	1.92 $\pm$ 0.36
Itchy	2.50 $\pm$ 0.34
Sting	2.25 $\pm$ 0.37
Soreness	1.58 $\pm$ 0.67
Teardrop	1.92 $\pm$ 0.34
Eye redness	1.83 $\pm$ 0.37

## 4. CONCLUSIONS

Survey on the actual condition showed 16.5% people who had corneal refractive surgery have experience wearing contact lenses after the surgery and 88.4% of them wore cosmetic contact lenses. They wore average

7.16±3.18 hours per day and 79.1% of them had subjective symptoms such as the feelings of dryness, movement, eye redness, teardrop, and pain respectively. It is expected that 25.7% of subjects will wear contact lenses in the future. In addition, they wore the mostly distributed type of cosmetic contact lenses, which has B.C 8.6mm, DIA 14.0mm. After corneal refractive surgery, the lenses will not stay in the centre of cornea since the shape has changed. Also, there should be a wide range of base curve to choose from but the option on the market is limited. We observed the location of the contact lenses on the cornea, which was modified with corneal refractive surgery. It was observed when the contact lenses are stabilized on the cornea. The lenses moved more in vertical direction than horizontal direction and all of the lenses in 24 eye moved towards inferior and temporal. The location of lenses was off the center and it was different from the expectation as we anticipated steep-fitting. It seems that there is interrelationship between the blinking and the movement of contact lenses, and that the movement of contact lenses increases the frequency of blinking. In subjective symptom assessment, the intensity of discomfort was in order of movement, itchiness, sting, dryness, teardrop, eye redness, and soreness. The movement of lenses and the feeling of movement has correlation and the further the lenses go the higher number the feeling of movement received. This study has shown that the lousy central stability of contact lenses on the corneal refractive surgery operated cornea could give the uncomfortable feeling of movement so that a more sophisticated fitting due to the limited type of contact lens with detailed description to the wearer. It is thought that convergence will be necessary in the industry and clinical study of contact lenses.

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